Water Quality Improvements with ASR

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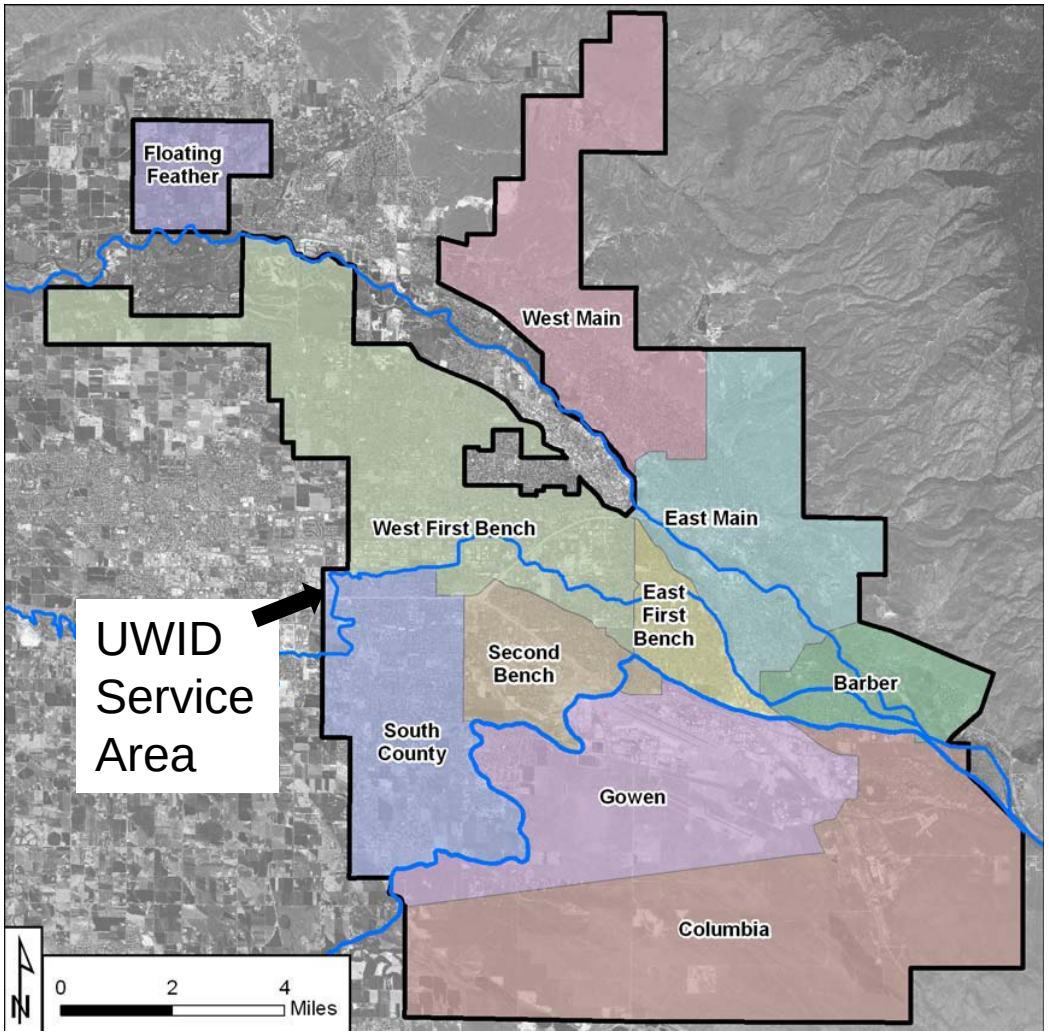
2011 PNWS AWWA Conference
Boise, Idaho

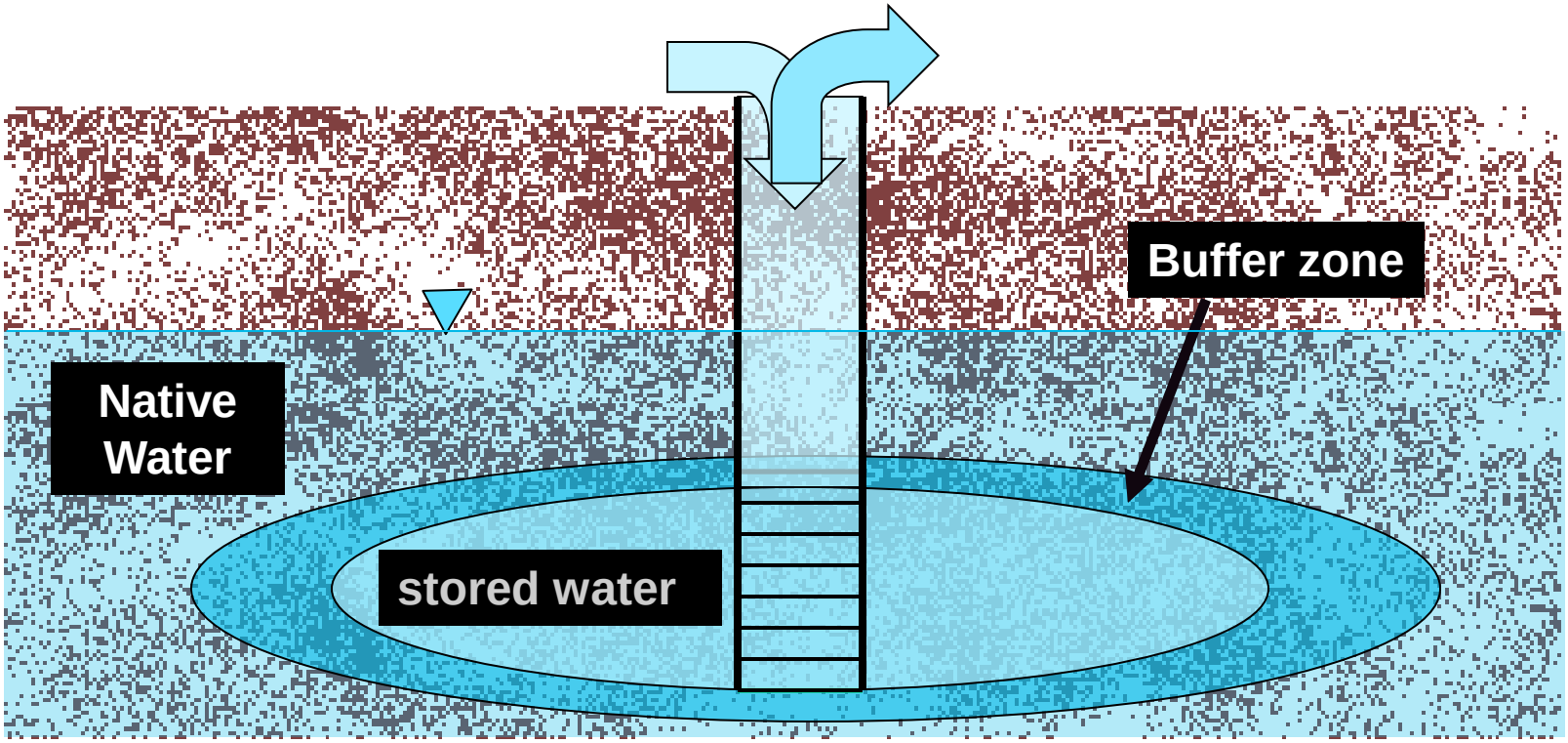
Overview of the United Water Idaho system

- **85,000 customer connections**
- **2 surface water treatment plants**
- **80 supply wells**
  - 3 wellhead treatment plants
  - Currently 5 operational ASR wells



ASR: Storage of water in a suitable aquifer through a well during times when water is available and recovery of the water through the same well during times when it is needed (Payne, 1995)

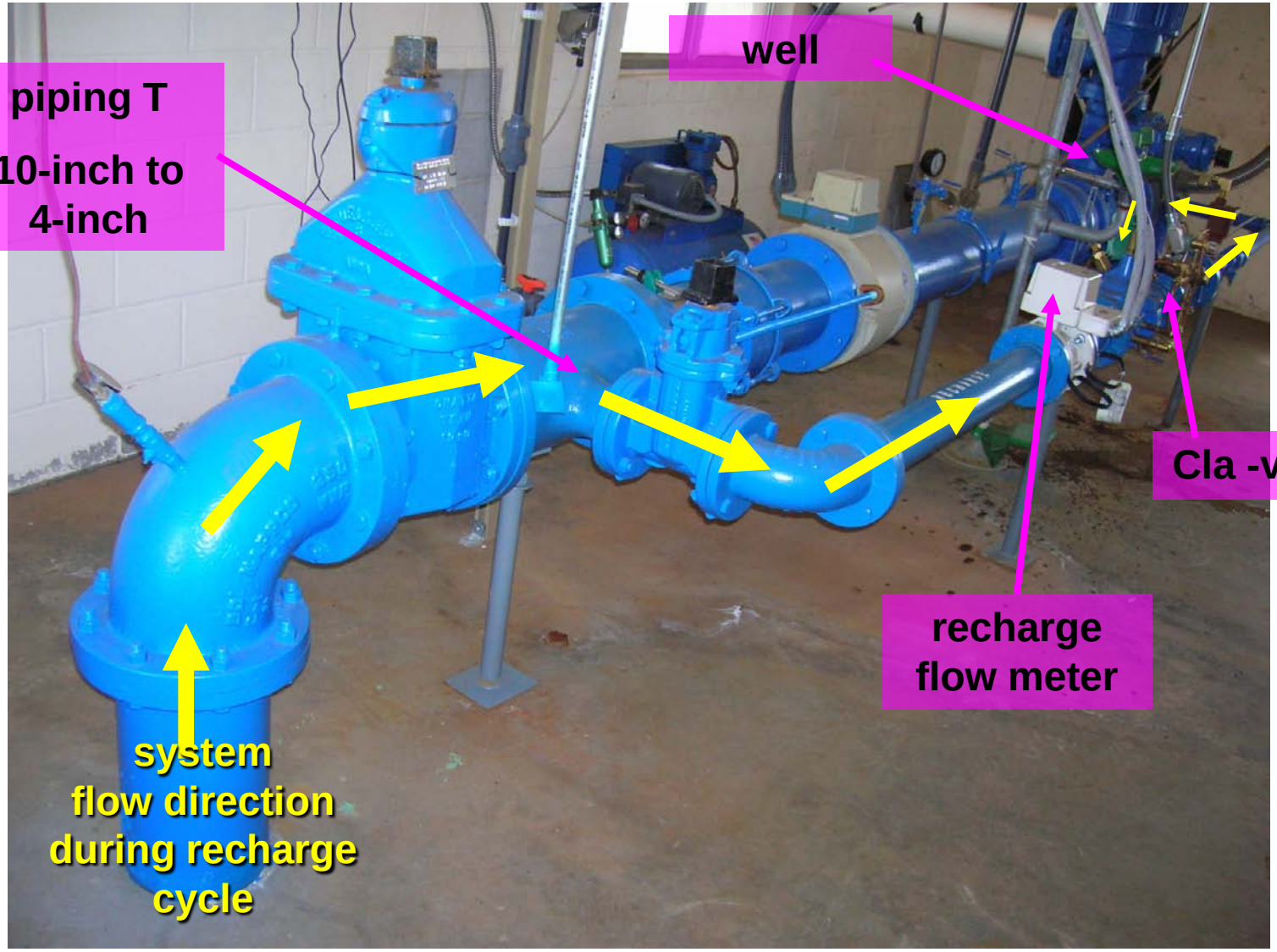
RSR: Storage efficiency: The percentage of stored water relative to the injected volume that is subsequently recovered while meeting a target water quality criterion in the recovered water



PRIMARY CAUSES FOR POOR WATER QUALITY DURING ASR RECOVERY

- Mixing
- Chemical reactions such as:
  - Acid base reactions
  - Mineral equilibrium reactions
  - Redox reactions
  - Surface reactions

SIMPLE MODIFICATION TO EXISTING PIPING ALLOWS RECHARGE



UWIDs FIRST ATTEMPT AT ASR:

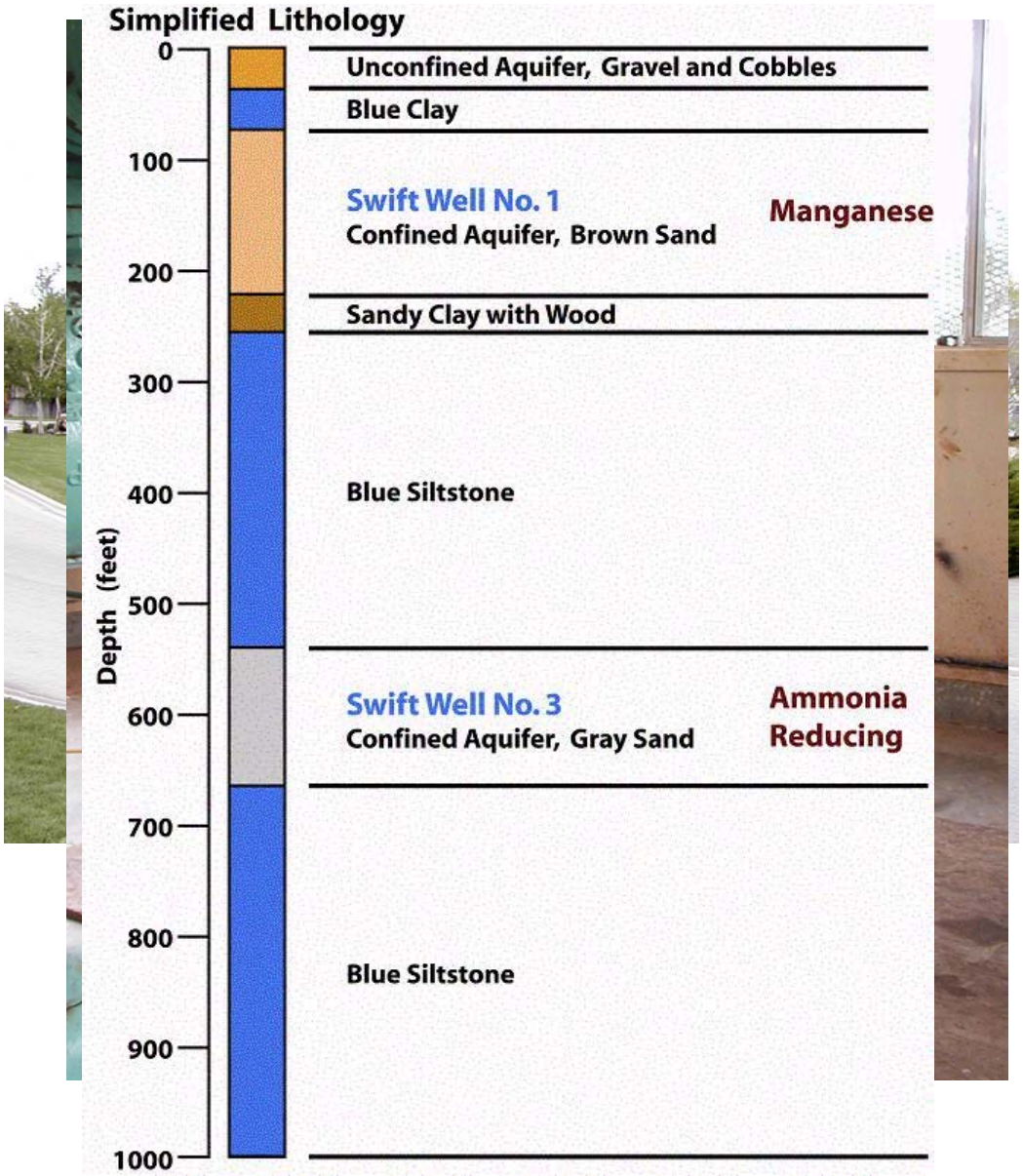
1978-86: Mn below secondary MCL

1986-92: Mn increases to 0.53 mg/L

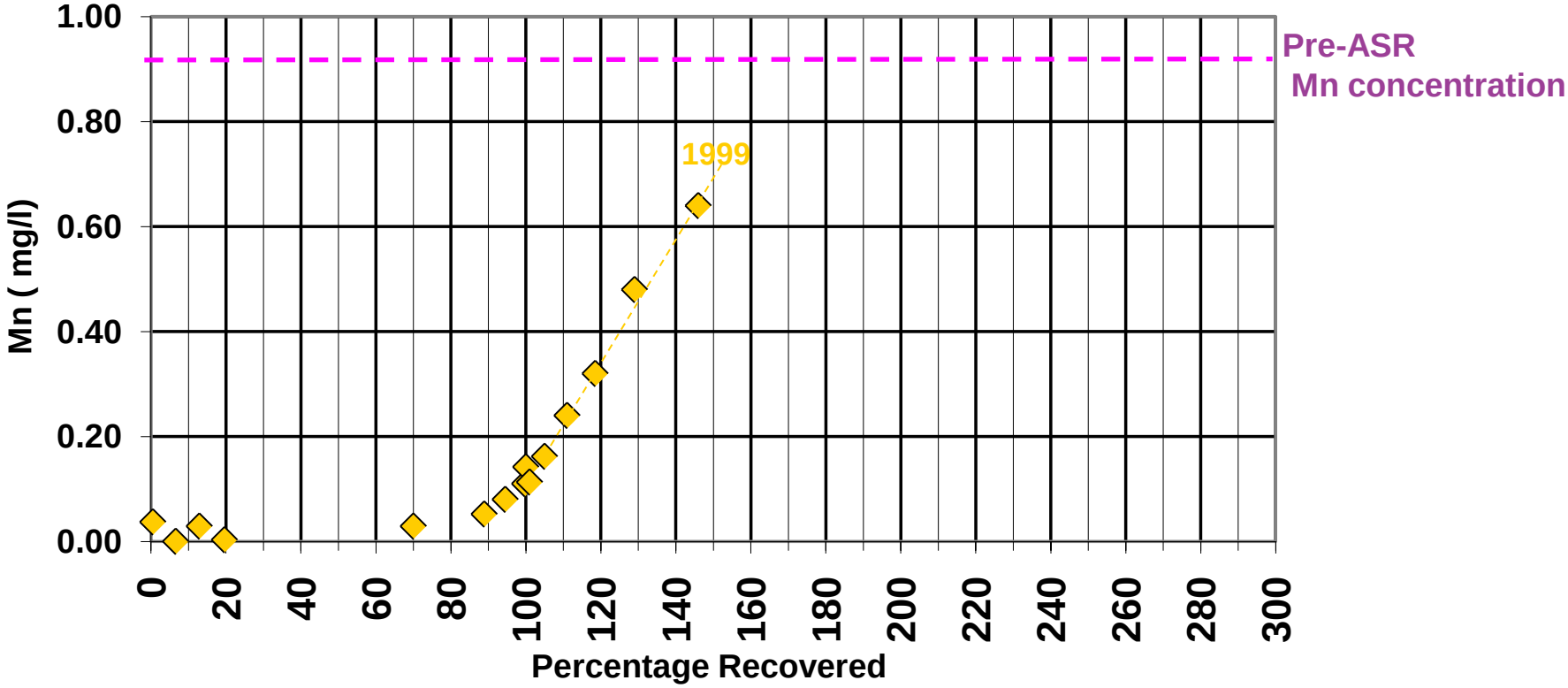
1992- 96: increase to 0.94 mg/L

1997: confirmed no acceptable replacement source

1998: 1 MG ASR pilot test



SWIFT 1 WELL: Mn VS. %-RECOVERY



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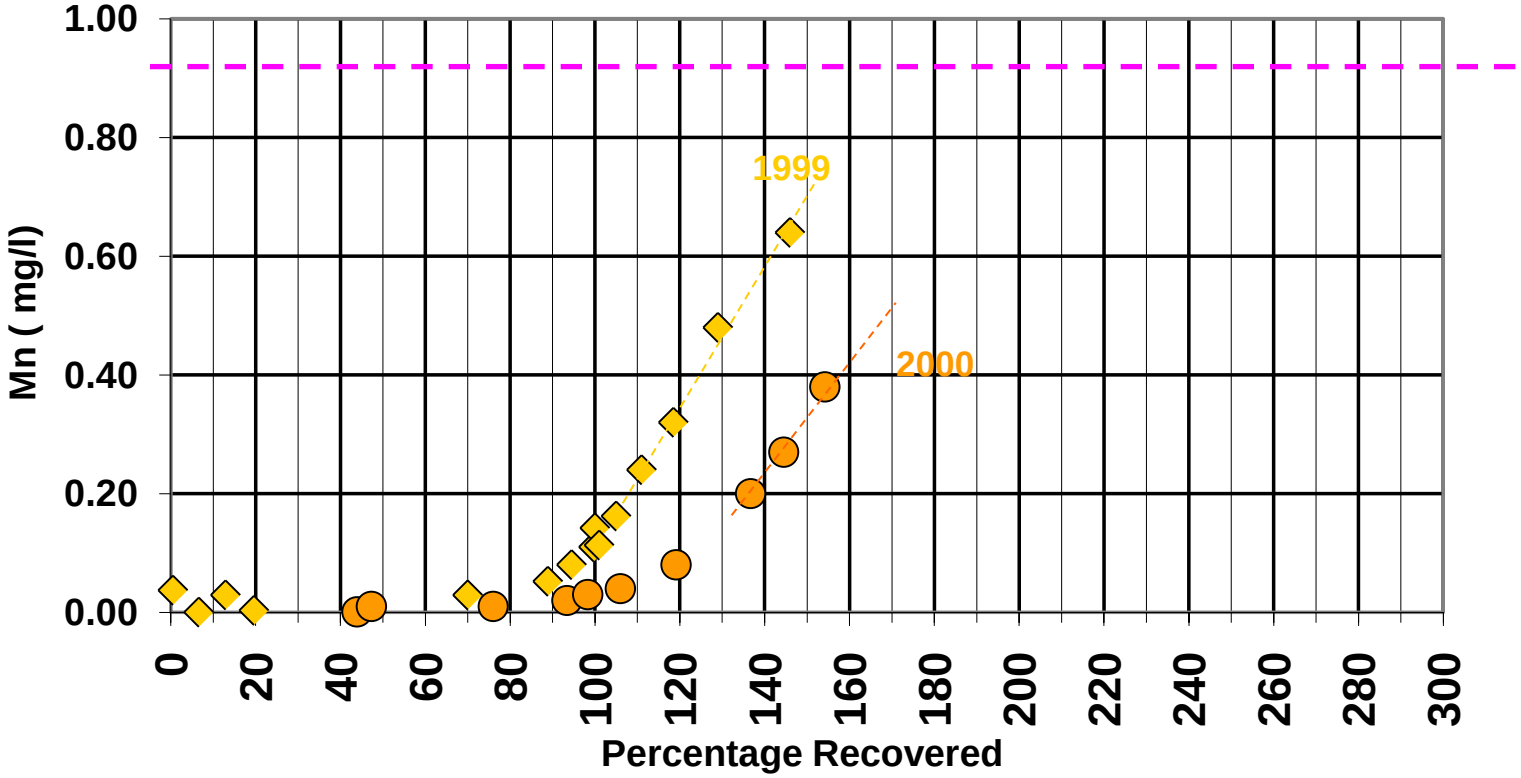

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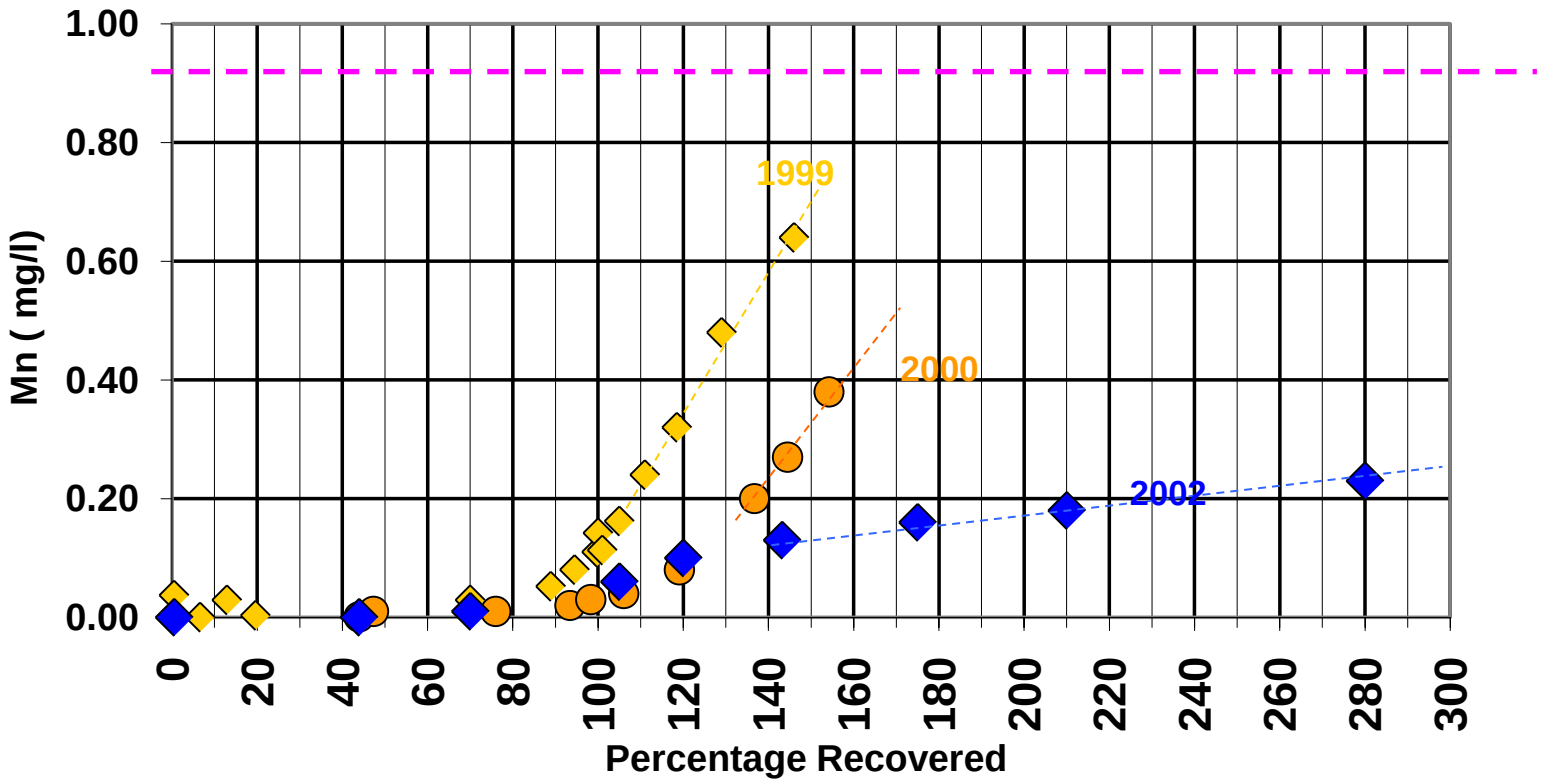
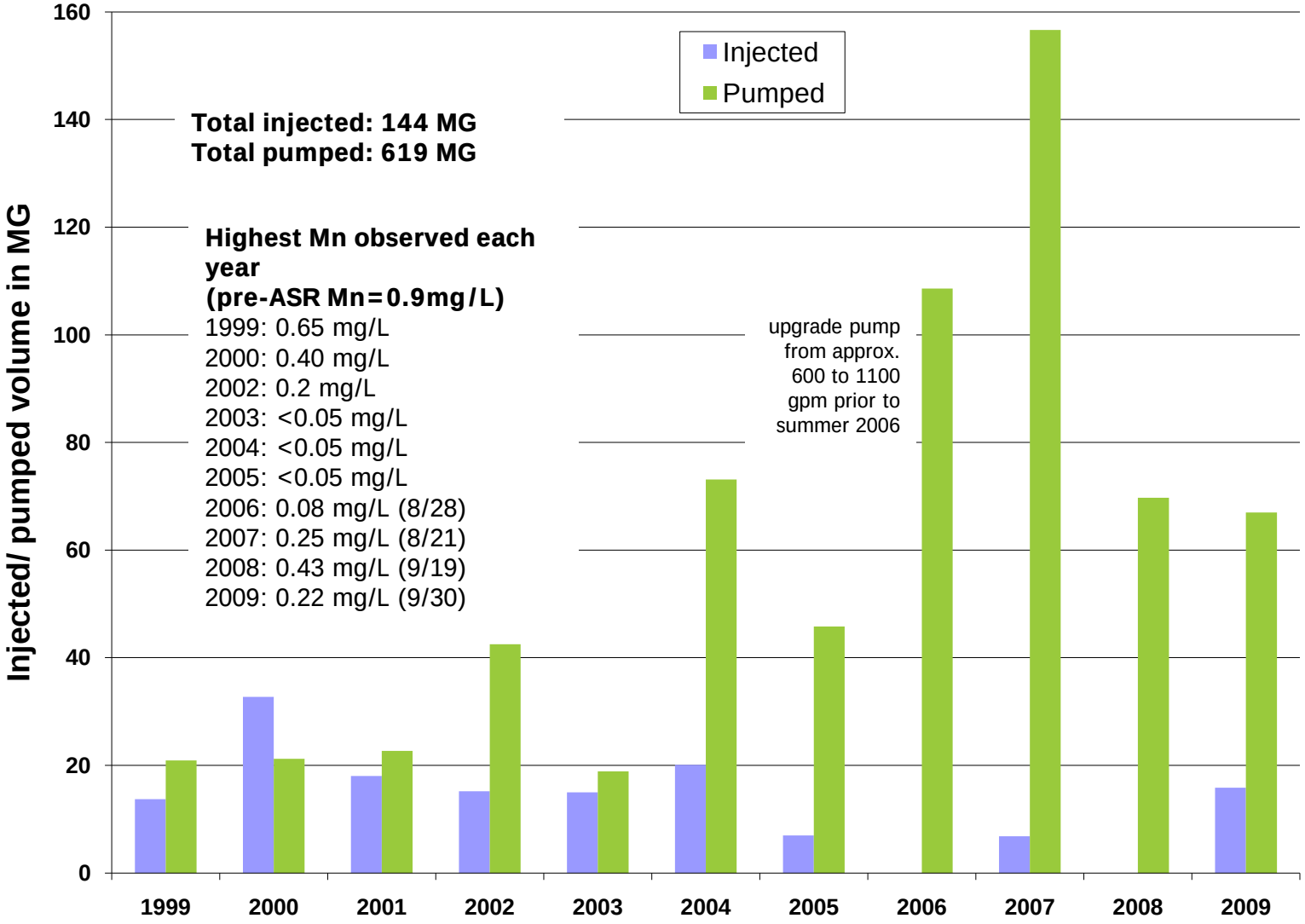
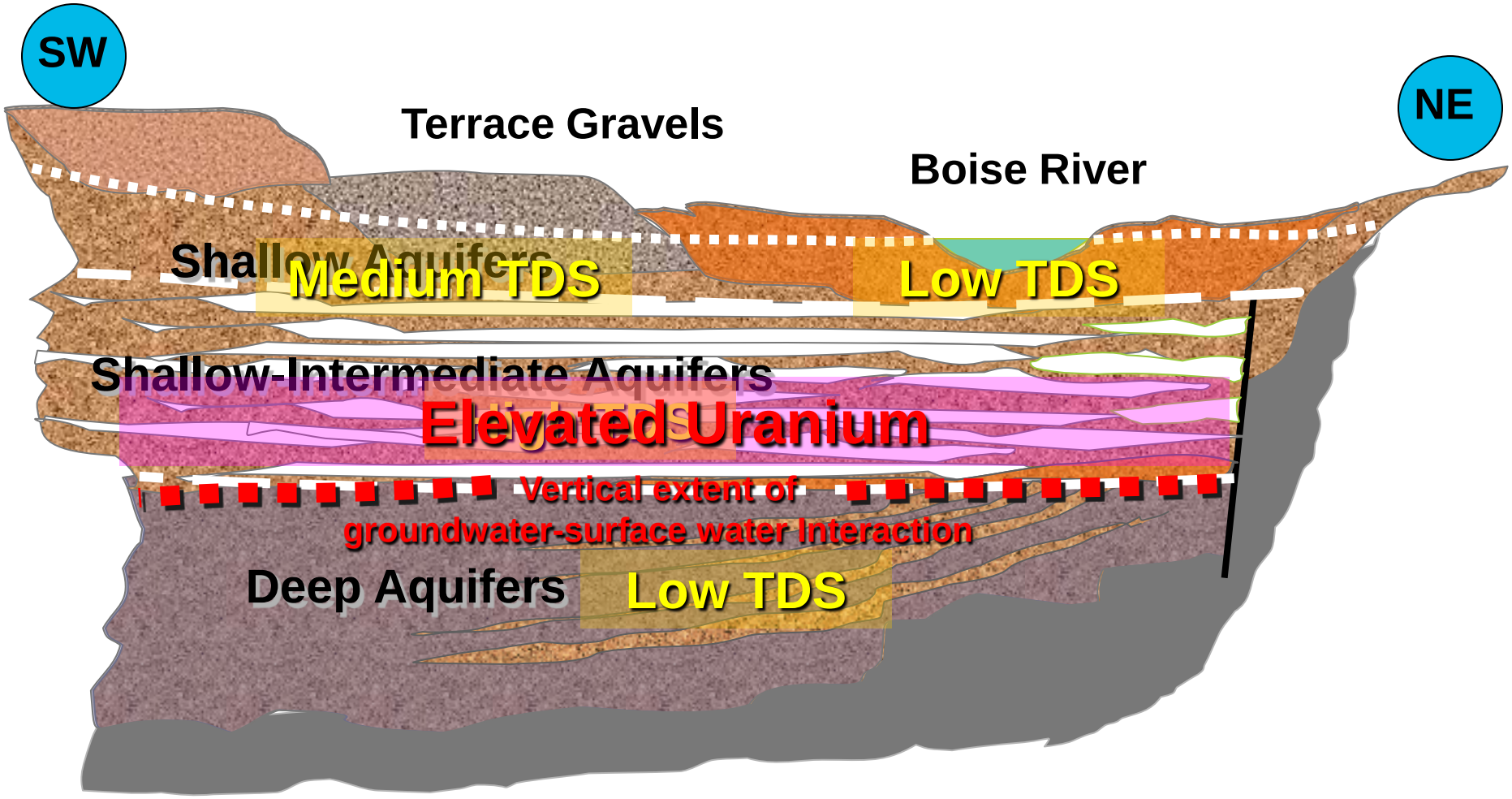


SWIFT WELL #1: ANNUAL INJECTED VS. PUMPED VOLUME



GENERALIZED OCCURRENCE OF URANIUM IN BOISE AREA



Adapted from C. Petrich

URANIUM, GROUNDWATER, ASR

- Uranium in groundwater originally comes from granite and granitic sediments
- Uranium mobile in oxidized groundwater
- Uranium concentrates in organic matter when oxygen is depleted.
- Over time, irrigation and pumping can bring oxidized groundwater to reduced organic material and release uranium
- If uranium present in ASR storage zone then it will be mobilized

ASR AT MAPLE HILL 2 WELL

Goal of ASR: non-peak season supply meeting uranium MCL

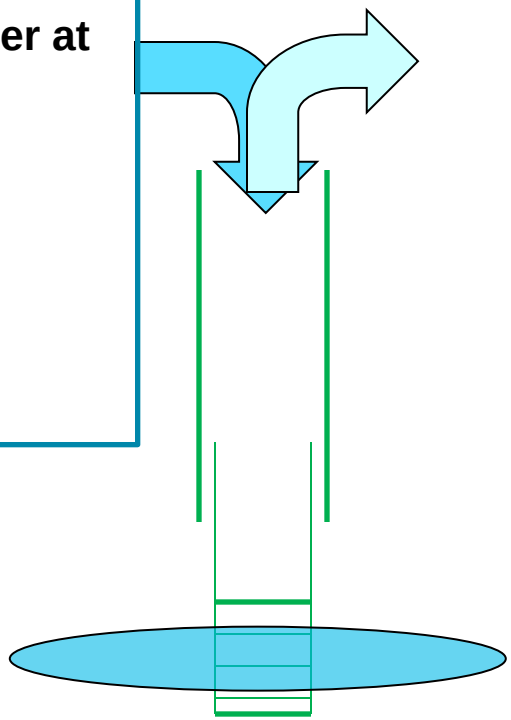
Recharge water:
deeper groundwater at same location

Temp 21º C

D.O. <0.2 mg/L

Cond. 300 *u*S

pH 7.6



317 ft deep

Native water:

Uranium (42 ug/L)

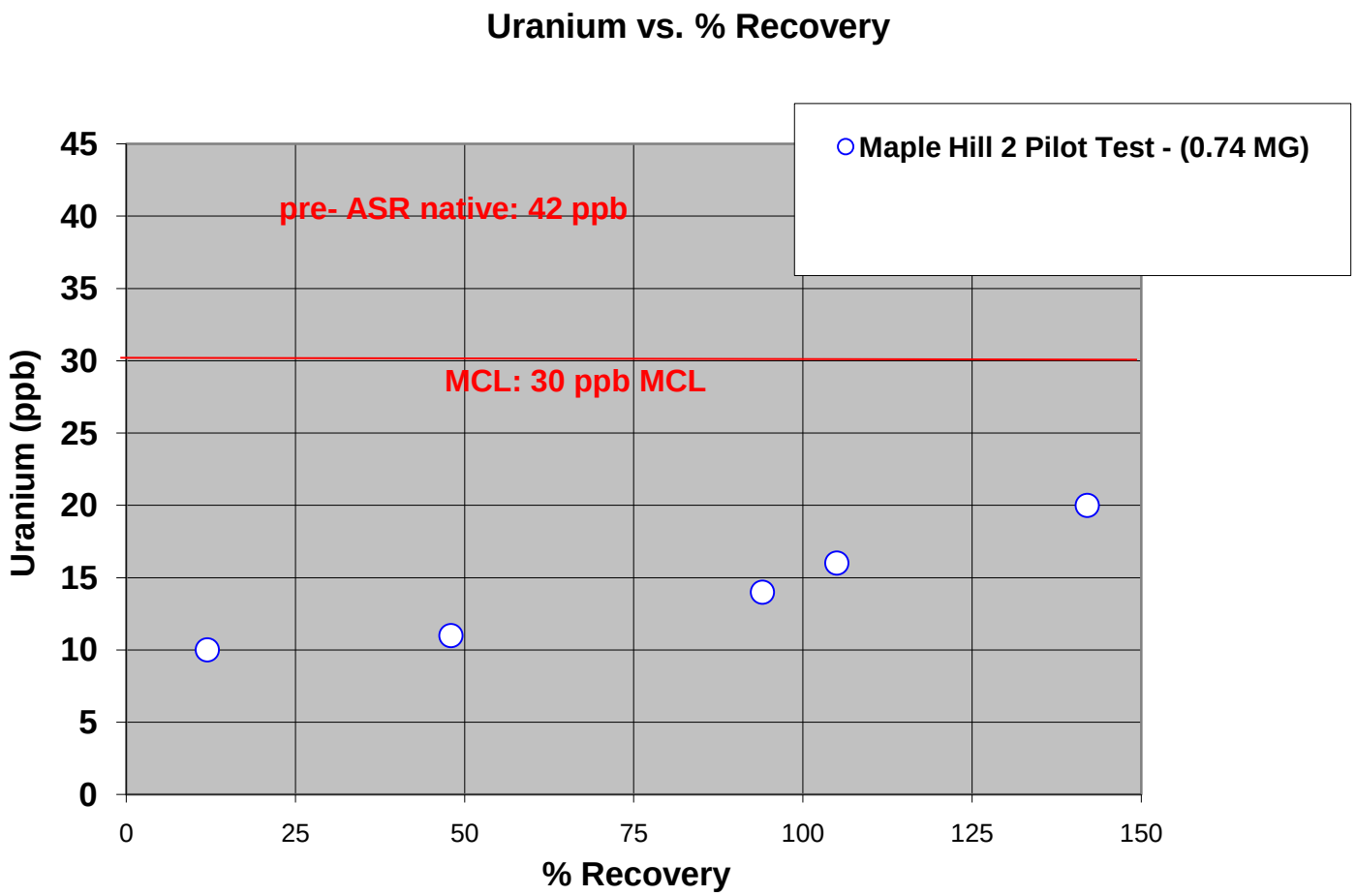
Temp 15º C

D.O. ~5+ mg/L

Cond. 600 *u*S

pH 7.5

ASR PILOT TESTING – TWO WELLS WITH URANIUM



SETTLERS WELL

Goal of ASR: peaking supply

Recharge water

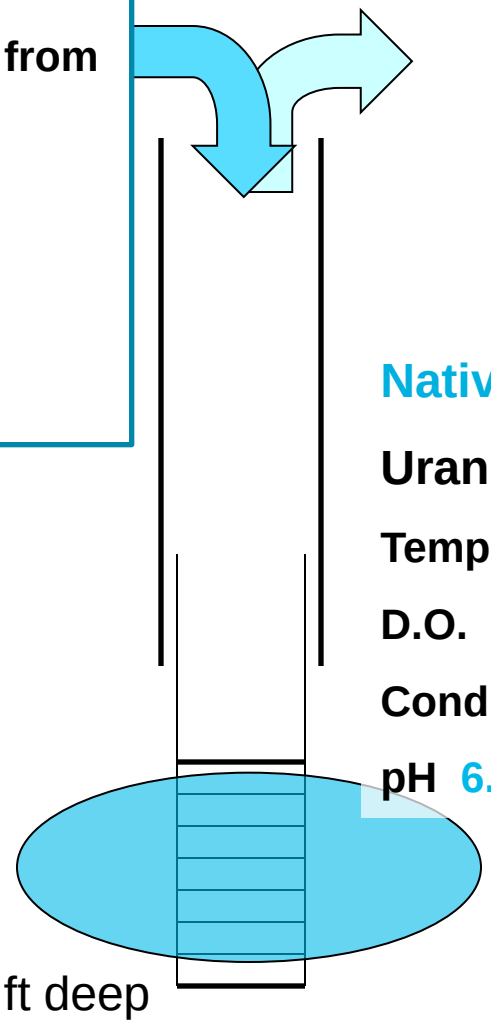
groundwater – mix from two wells

Temp ~18.5º C

D.O. 2.5 mg/L

Cond. 324 uS

pH 7.0



Native water

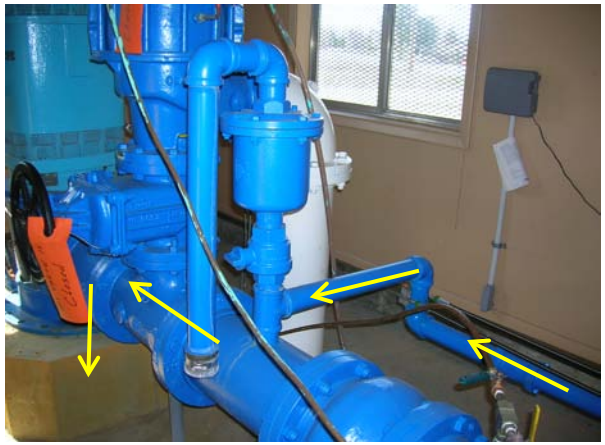
Uranium (40 ug/L)

Temp 15.5º C

D.O. 3.5 mg/L

Cond. 480 uS

pH 6.9



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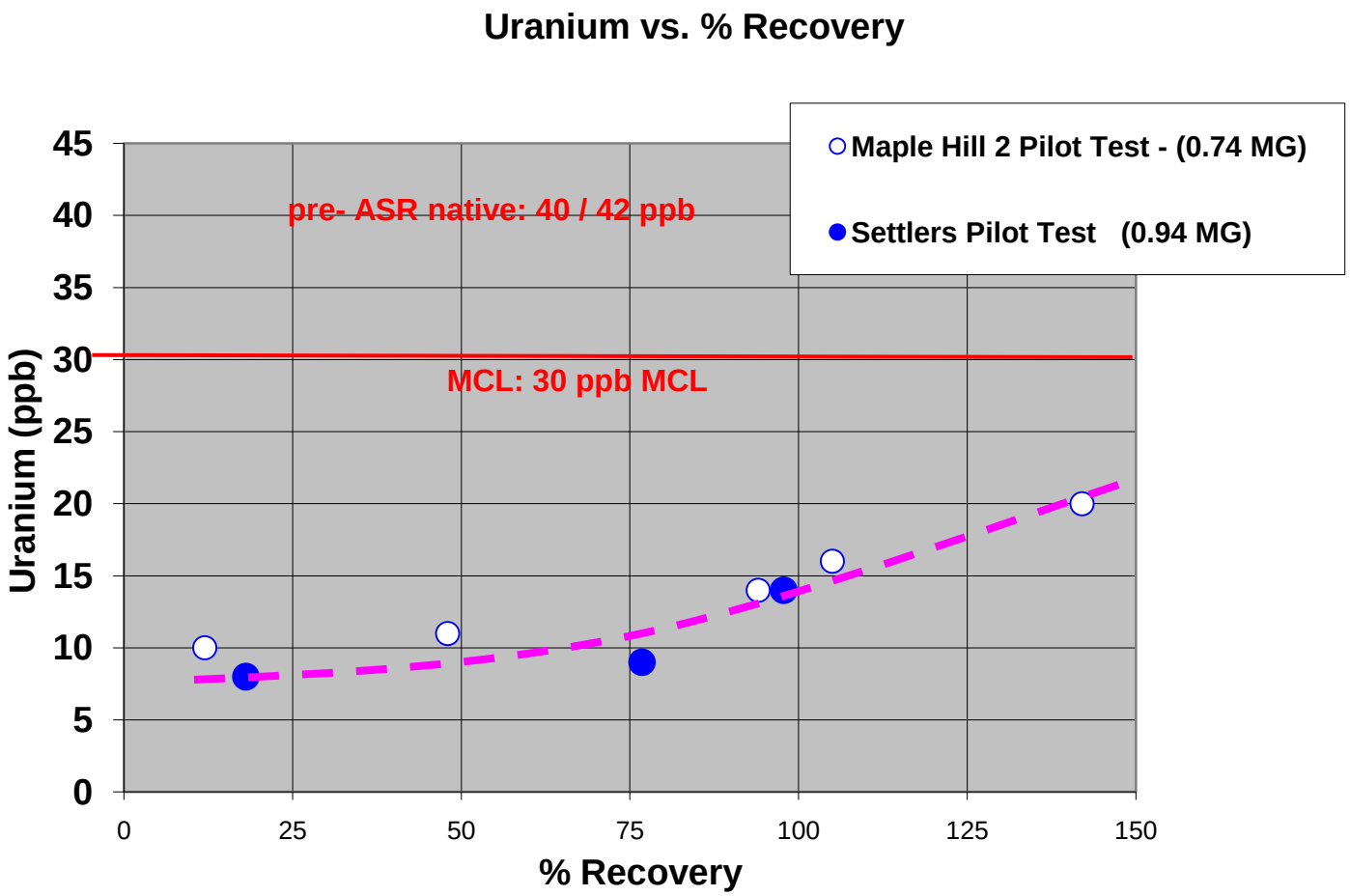
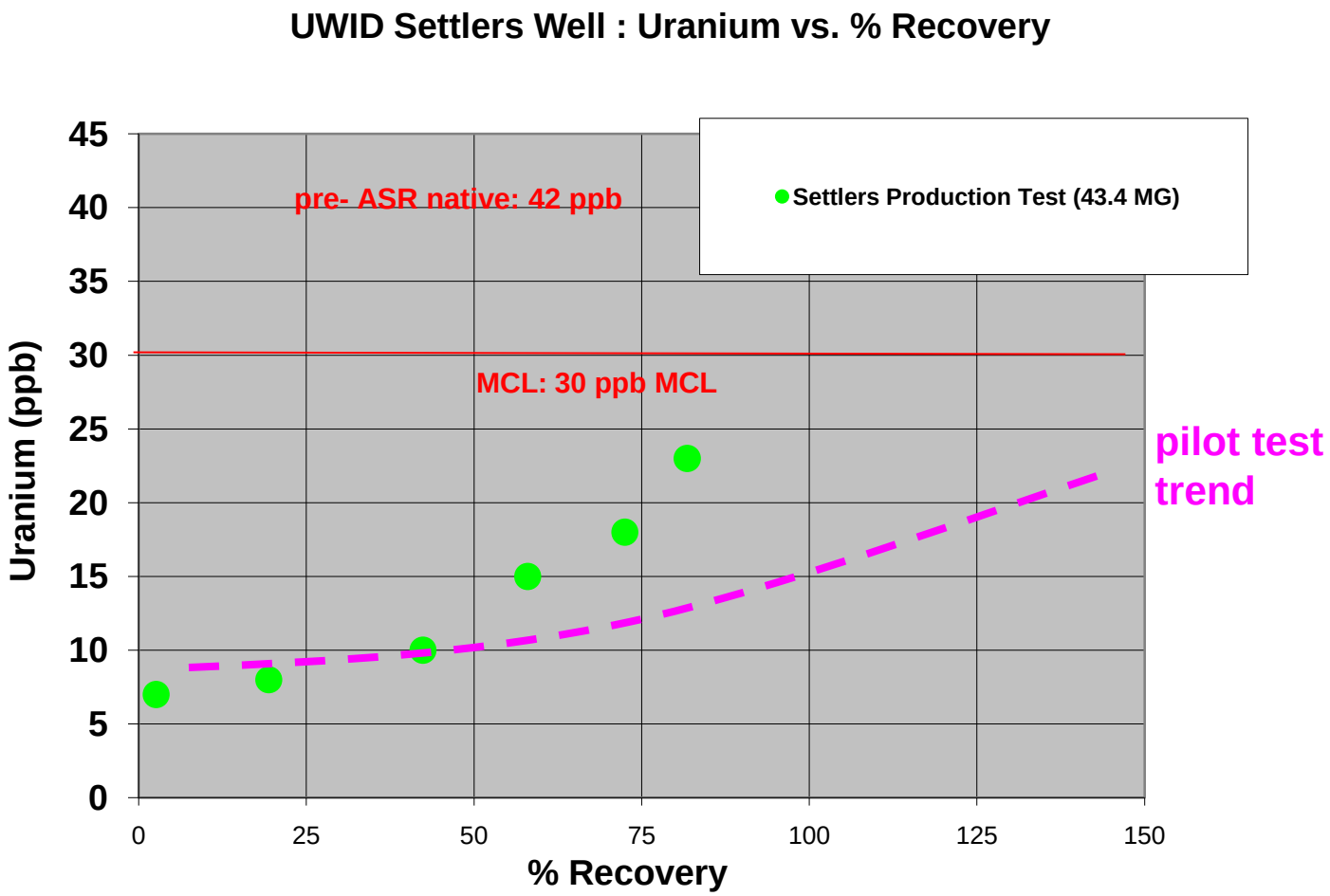


ASR PILOT TEST VS. OPERATION



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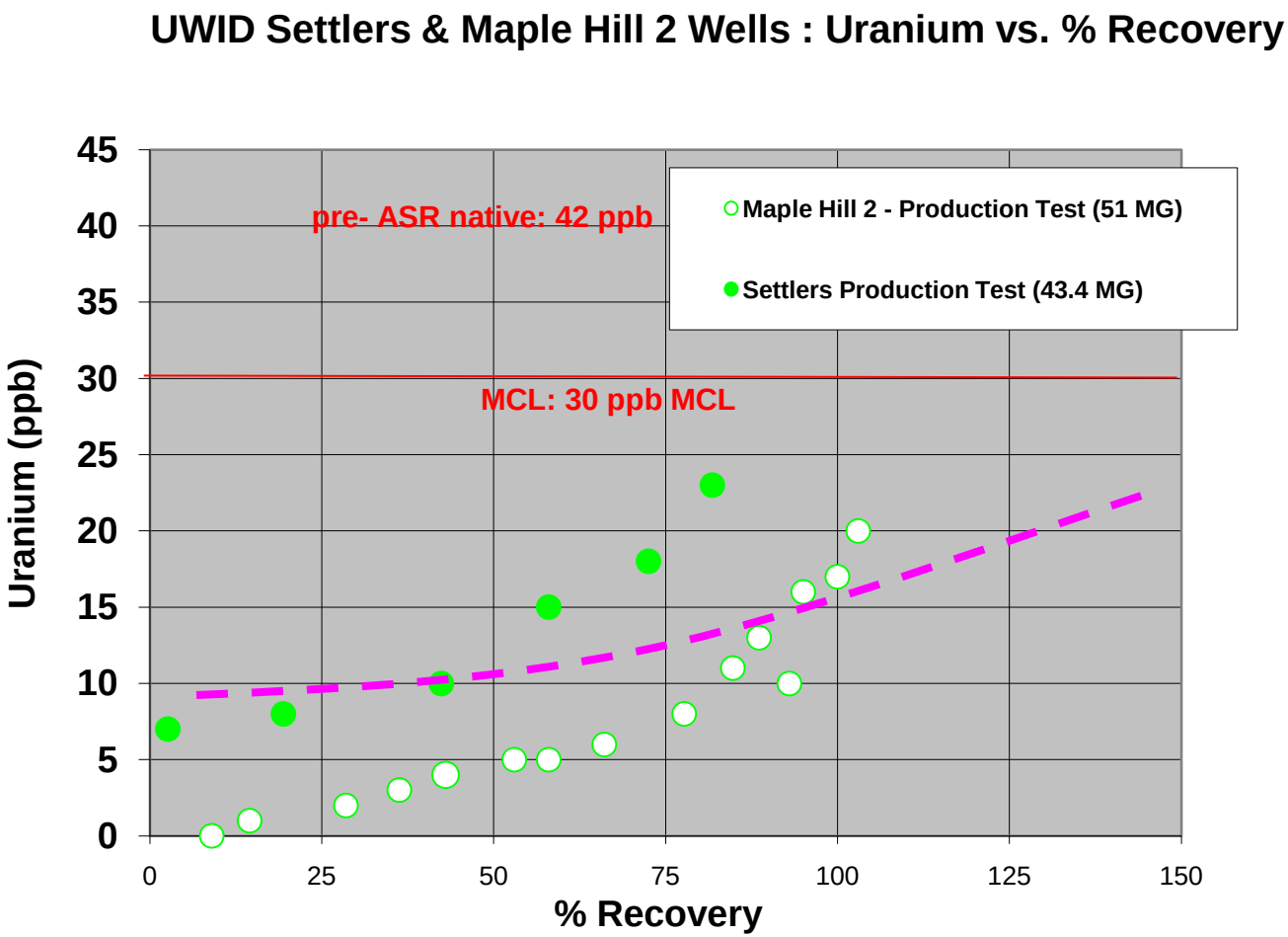
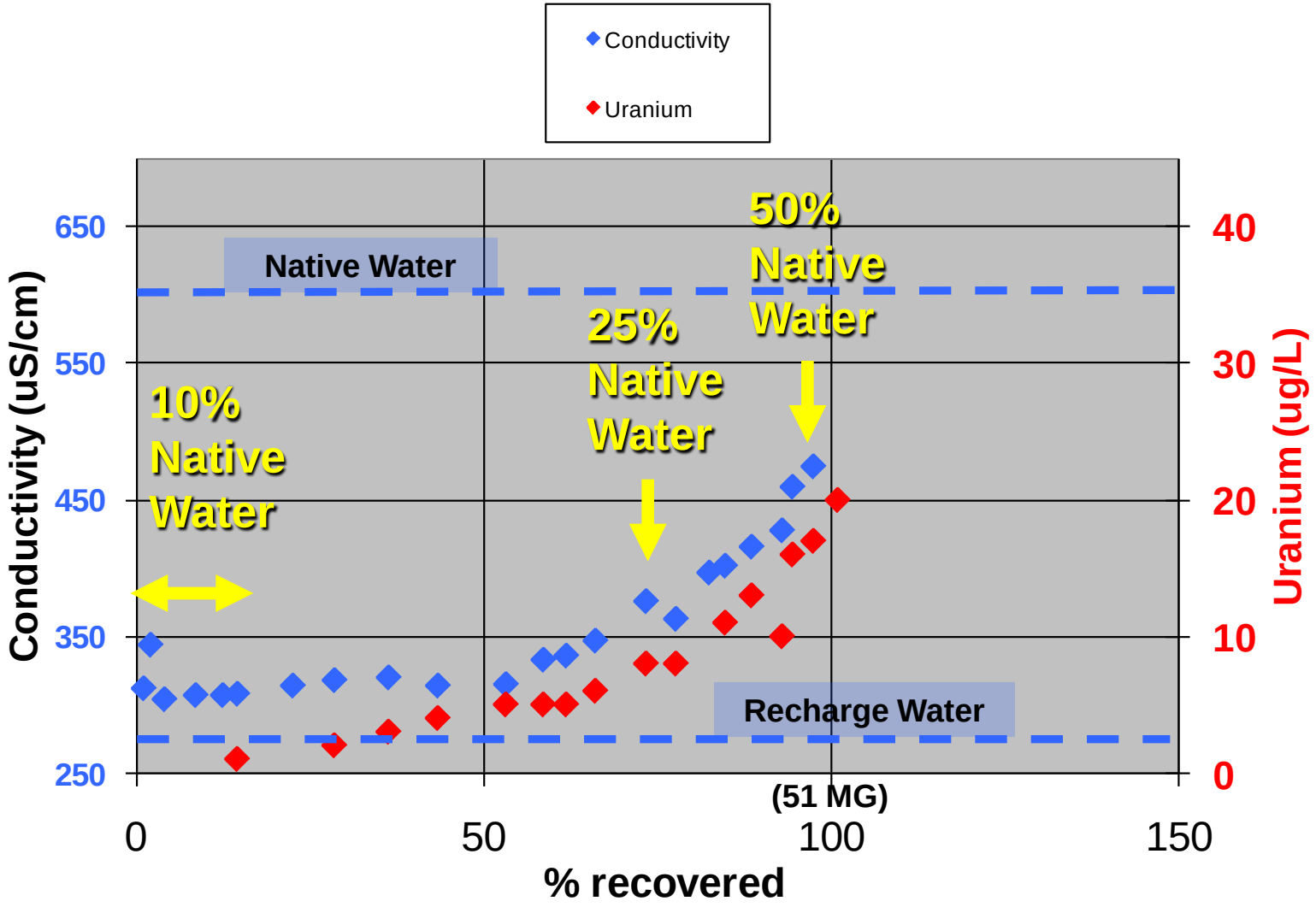


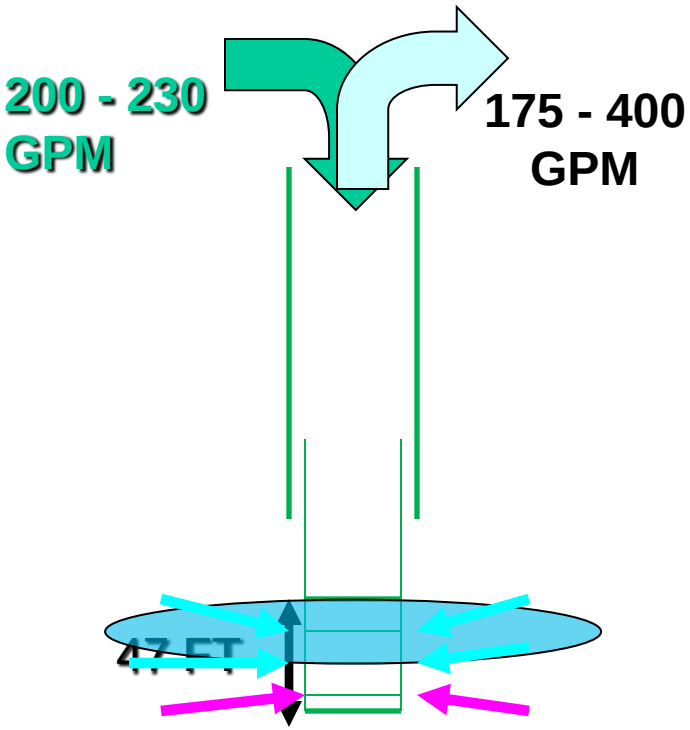
ASR & URANIUM
ESTIMATED RATIO OF NATIVE TO INJECTED WATER



WELL HYDRAULICS INFLUENCES RECOVERY

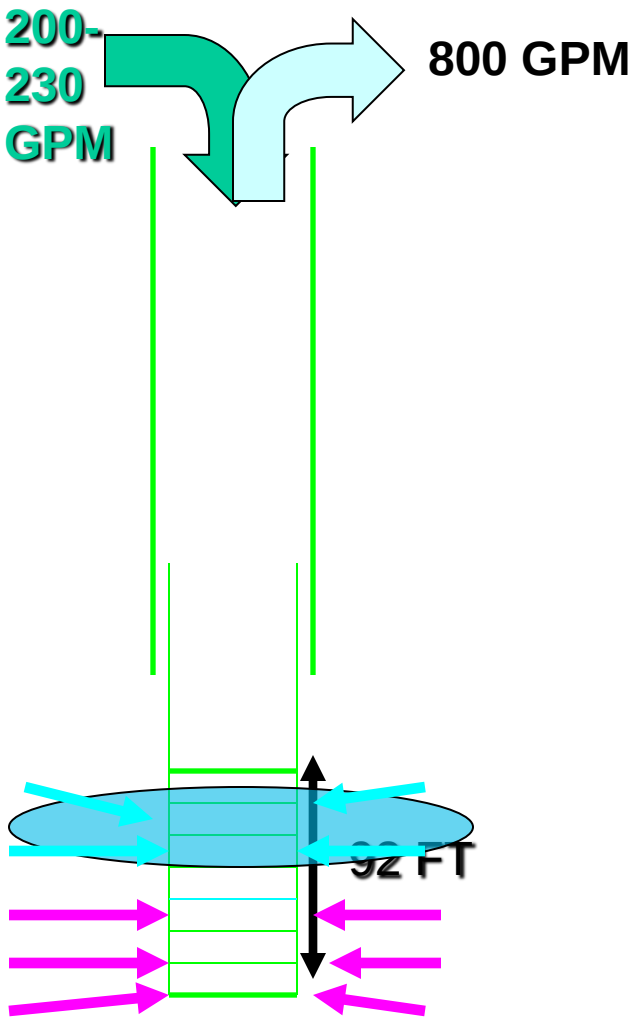
Maple Hill 2 well

Recovery Efficiency: 100+ %

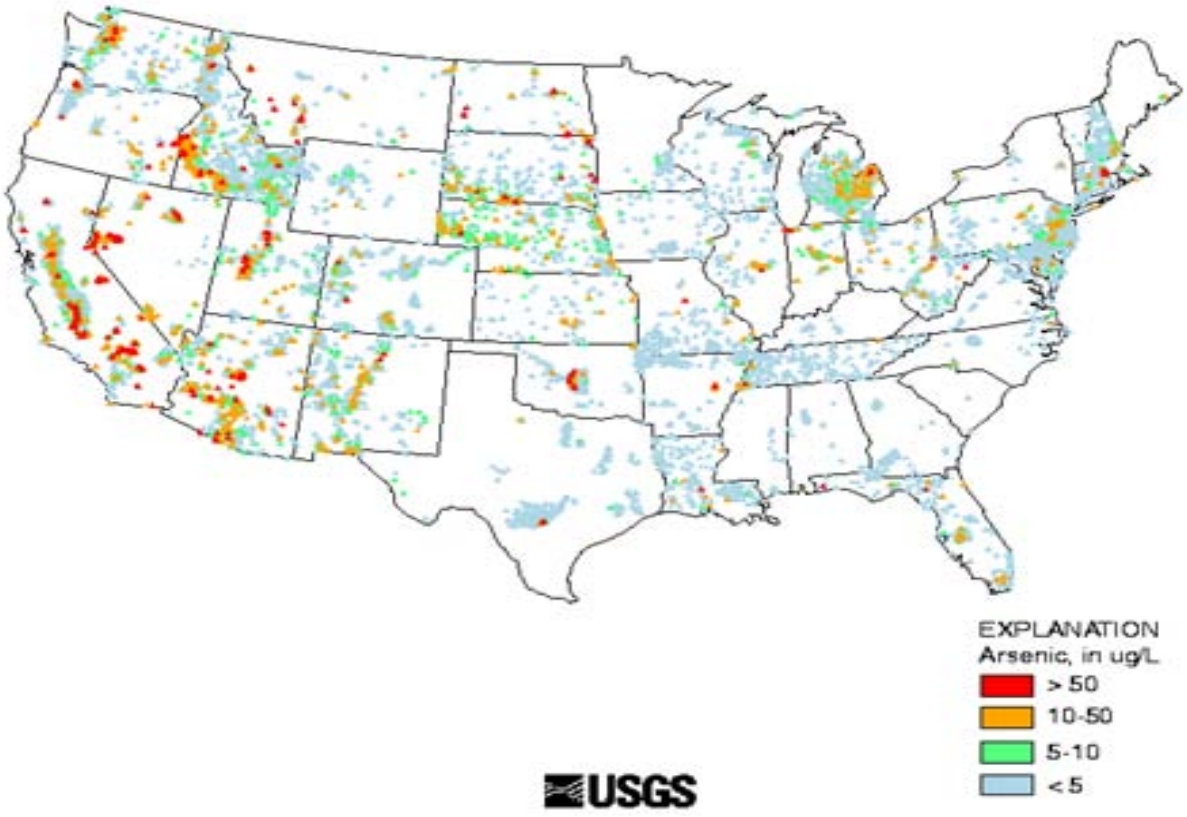


Settlers well

Recovery Efficiency 85 %

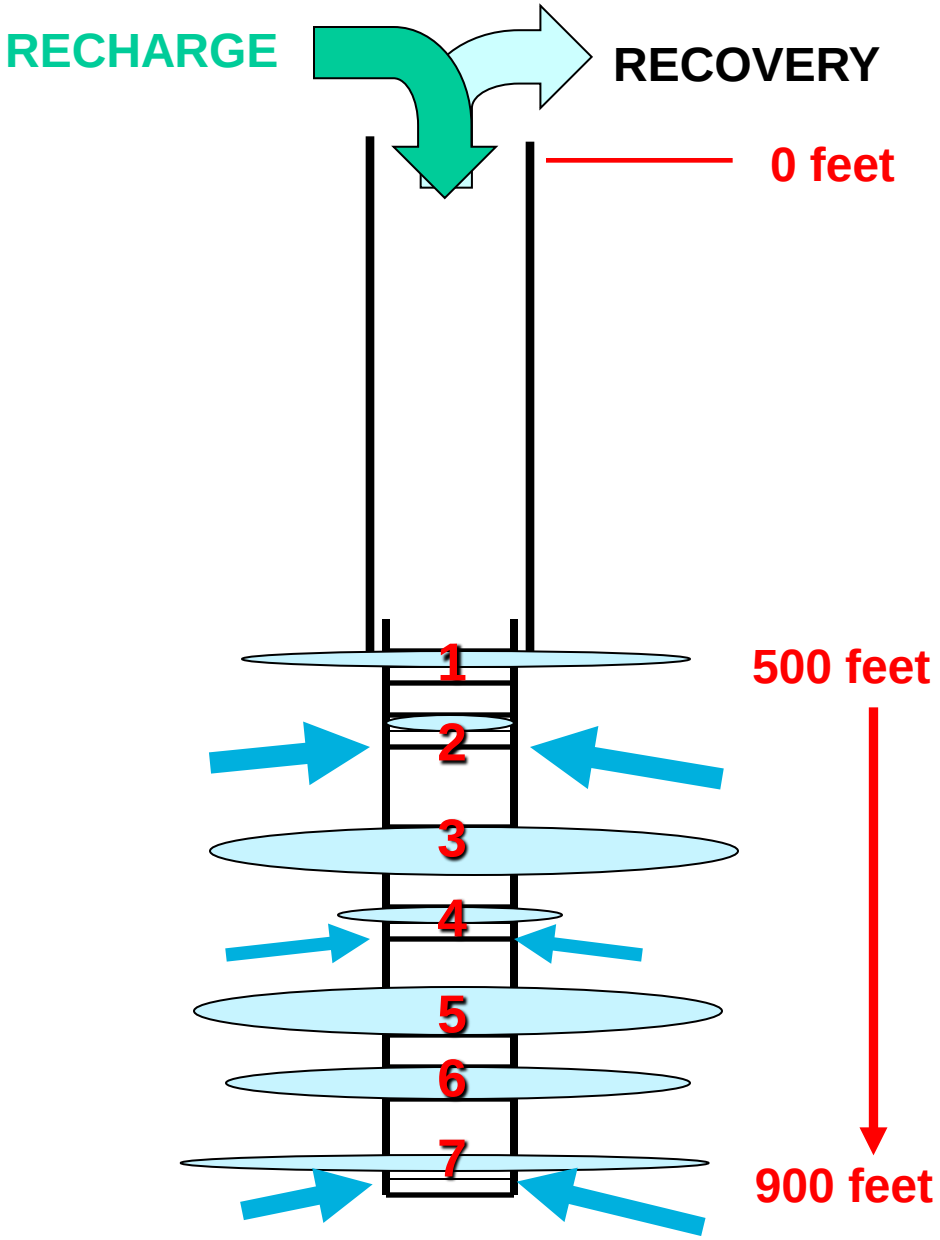


USING ASR TO MITIGATE FOR ARSENIC

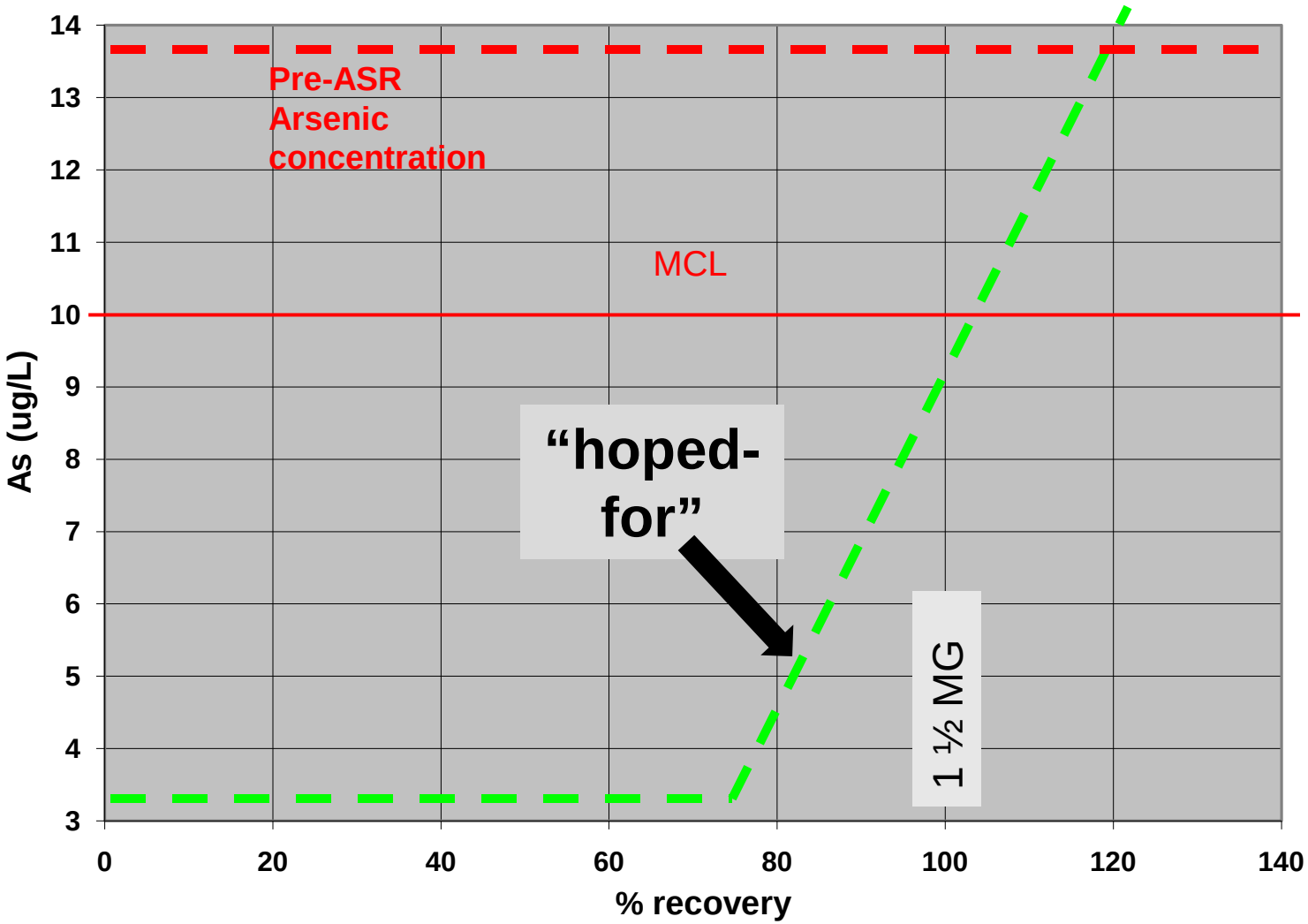


USING ASR TO MITIGATE FOR ARSENIC – AN EXAMPLE

- Again, well design may not be ideal for ASR
- Potential for preferential recharge …
- …and high ratio of native to stored water during recovery



PILOT TESTING ASR TO MITIGATE FOR ARSENIC



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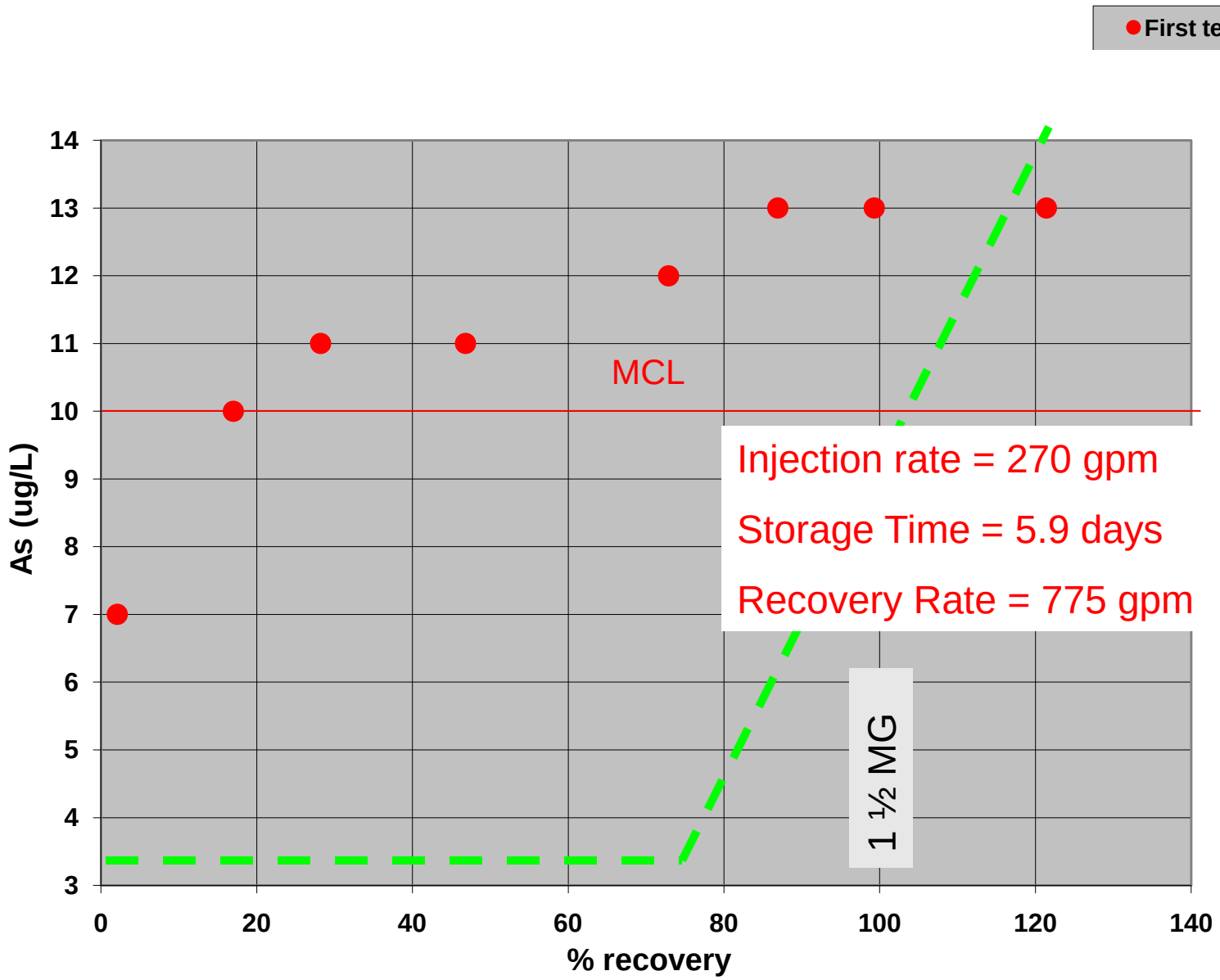

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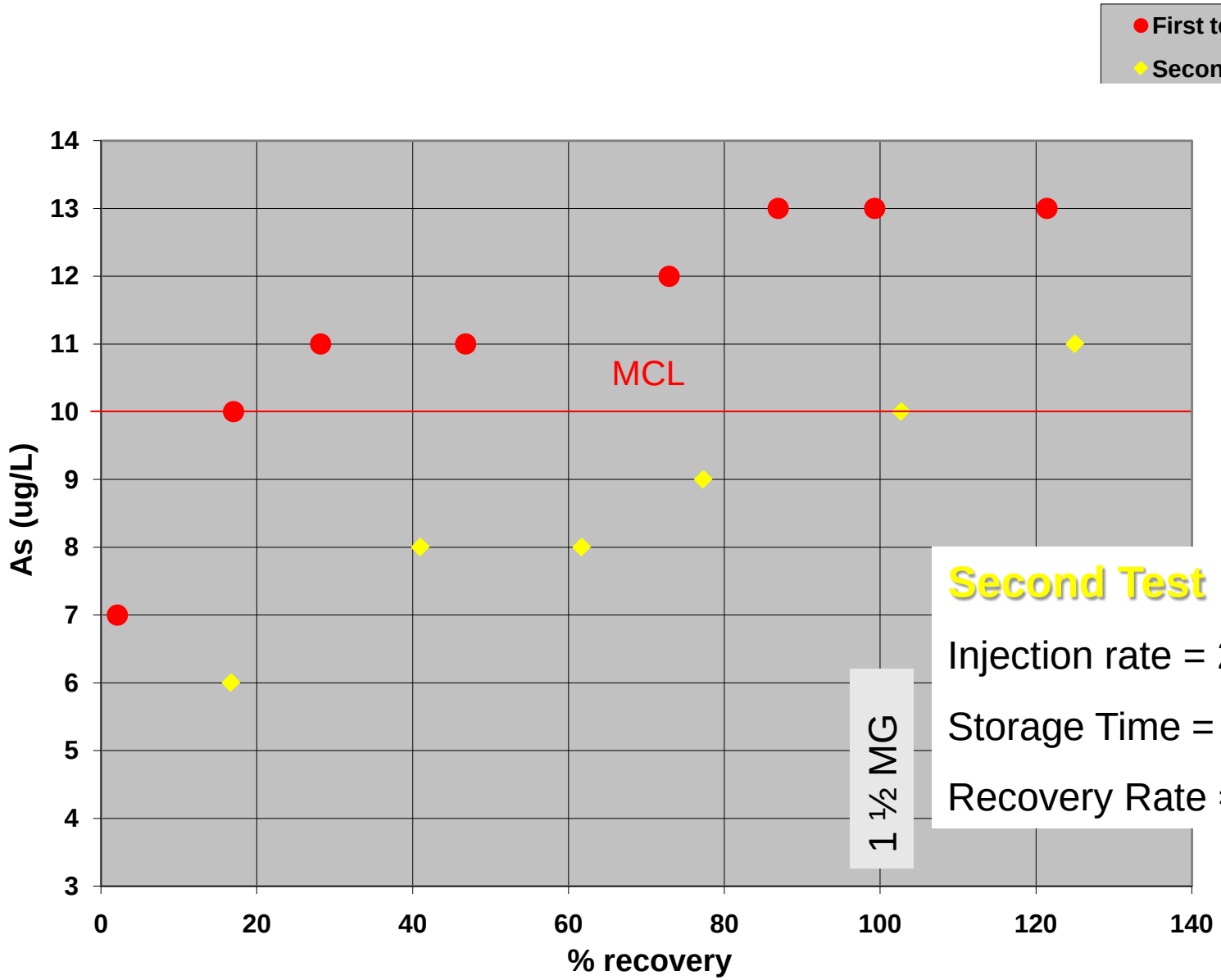


1 ½ MG

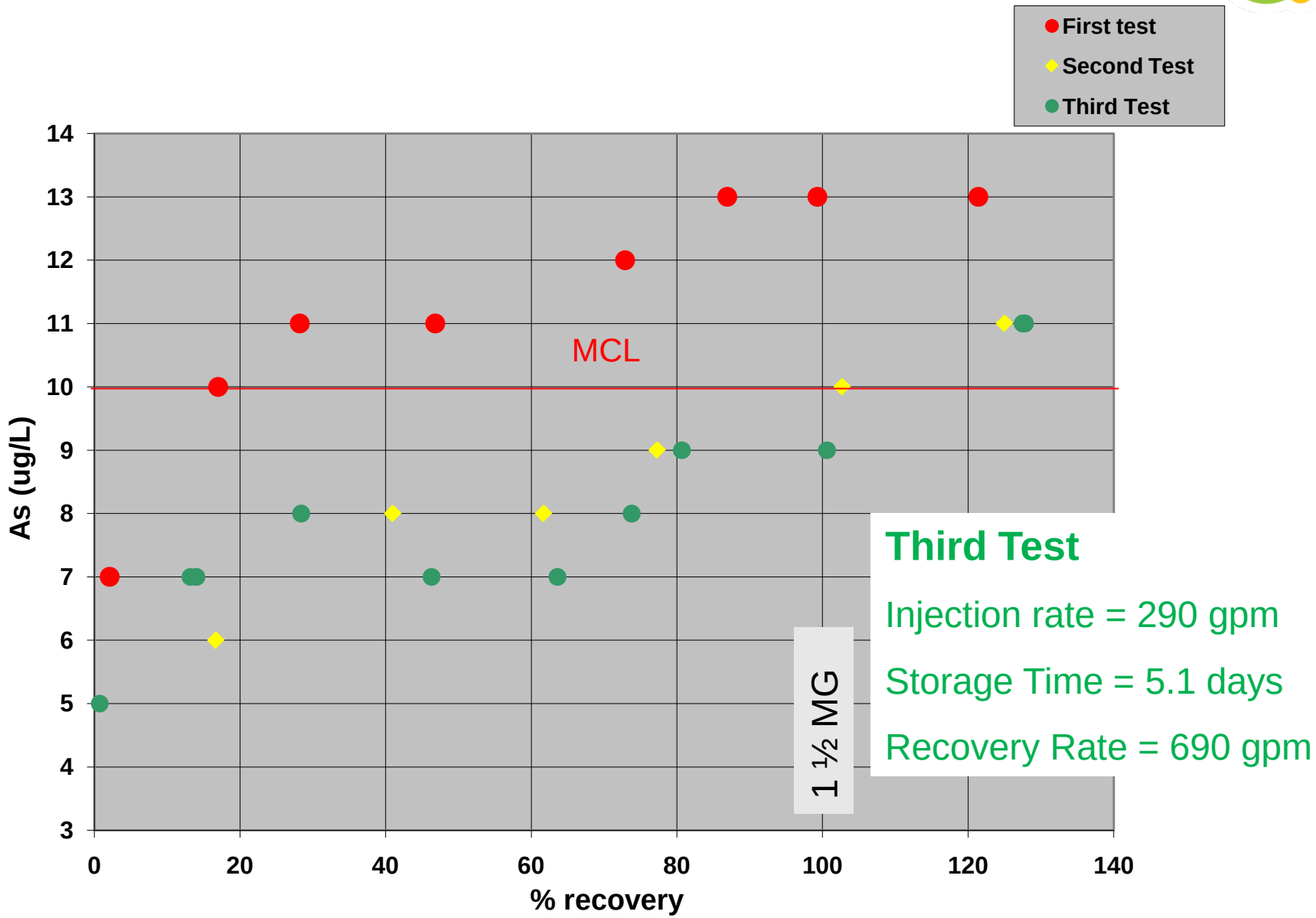
Second Test

Injection rate = 270 gpm

Storage Time = 4.2 days

Recovery Rate = 665 gpm

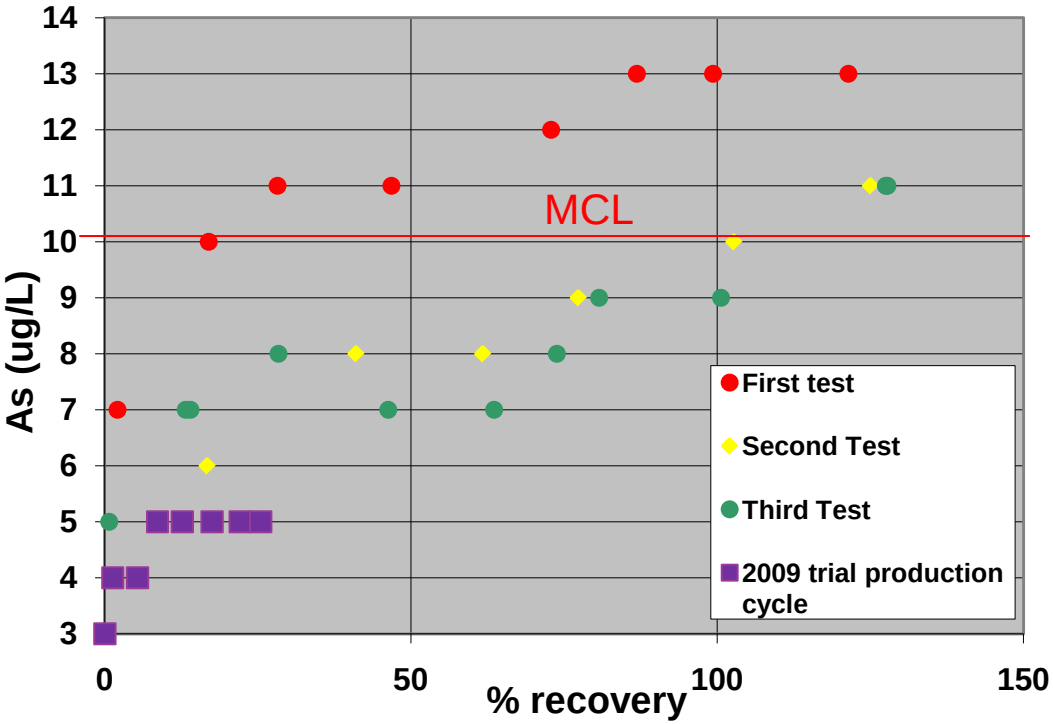
PILOT TESTING ASR TO MITIGATE FOR ARSENIC



SOME OBSERVATIONS FOR 1.5 MG PILOT TESTS MARKET ST. WELL

- Pilot test recovery efficiency showed improvement after initial cycle
- Moderate de-gassing observed during recovery
- Pilot testing indicated ASR may be feasible: try larger ASR test

59 MG TRIAL PRODUCTION CYCLE FOR ARSENIC MITIGATION



- Excessive degassing – recovery ended at 35 % recovery (21 MG)
- Arsenic mobilization not indicated for larger volume/ longer storage time
  - 100% recovery may be possible
- Distribution system manipulation to improve recharge source water/ ASR or change injection method?

SUMMARY

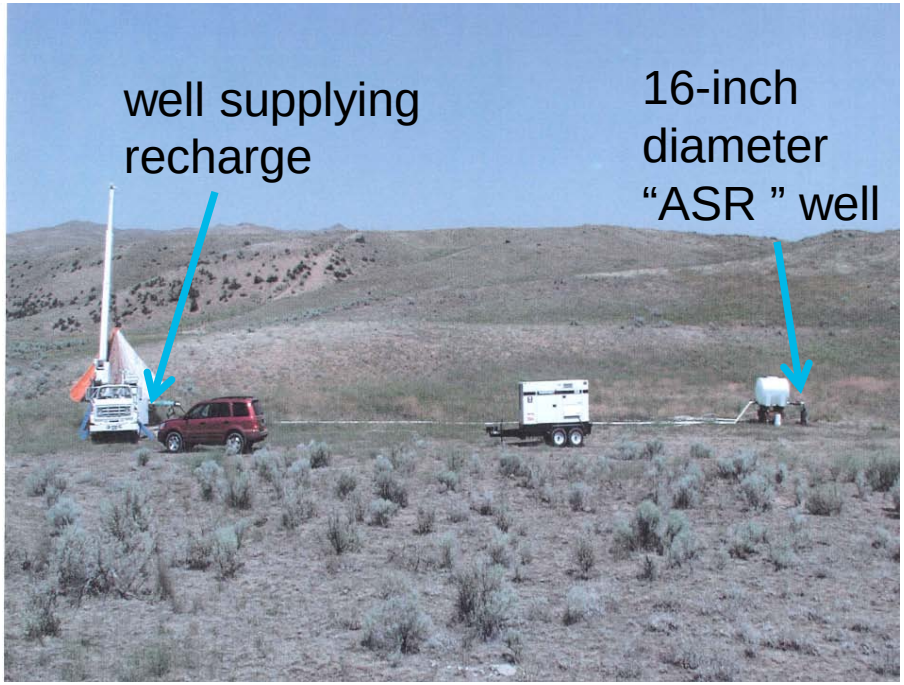
- **Overall, ASR found to be feasible at > 50% of tested sites.**

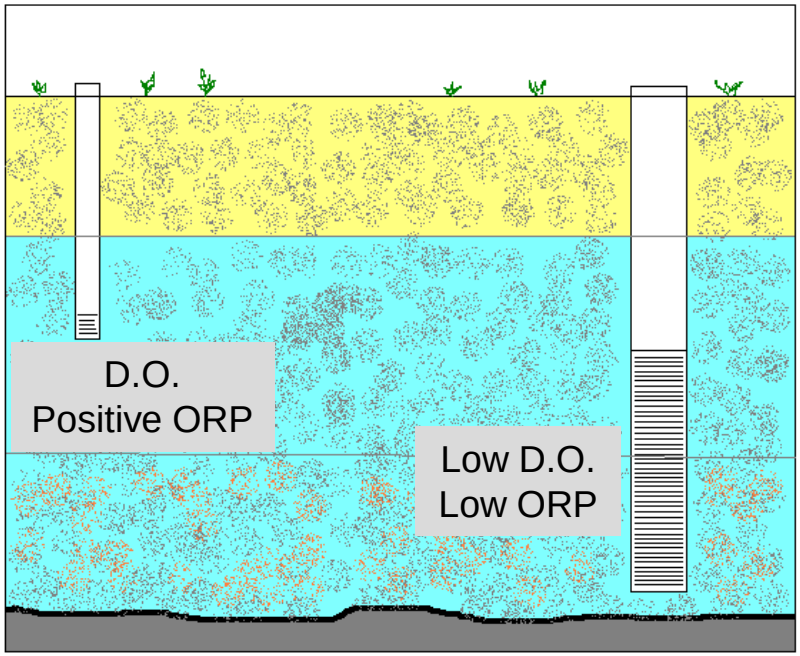
- **Smaller-scale ASR may only approximate operational ASR results.**

- **Well construction & acceptable recharge water chemistry appear to be critical**

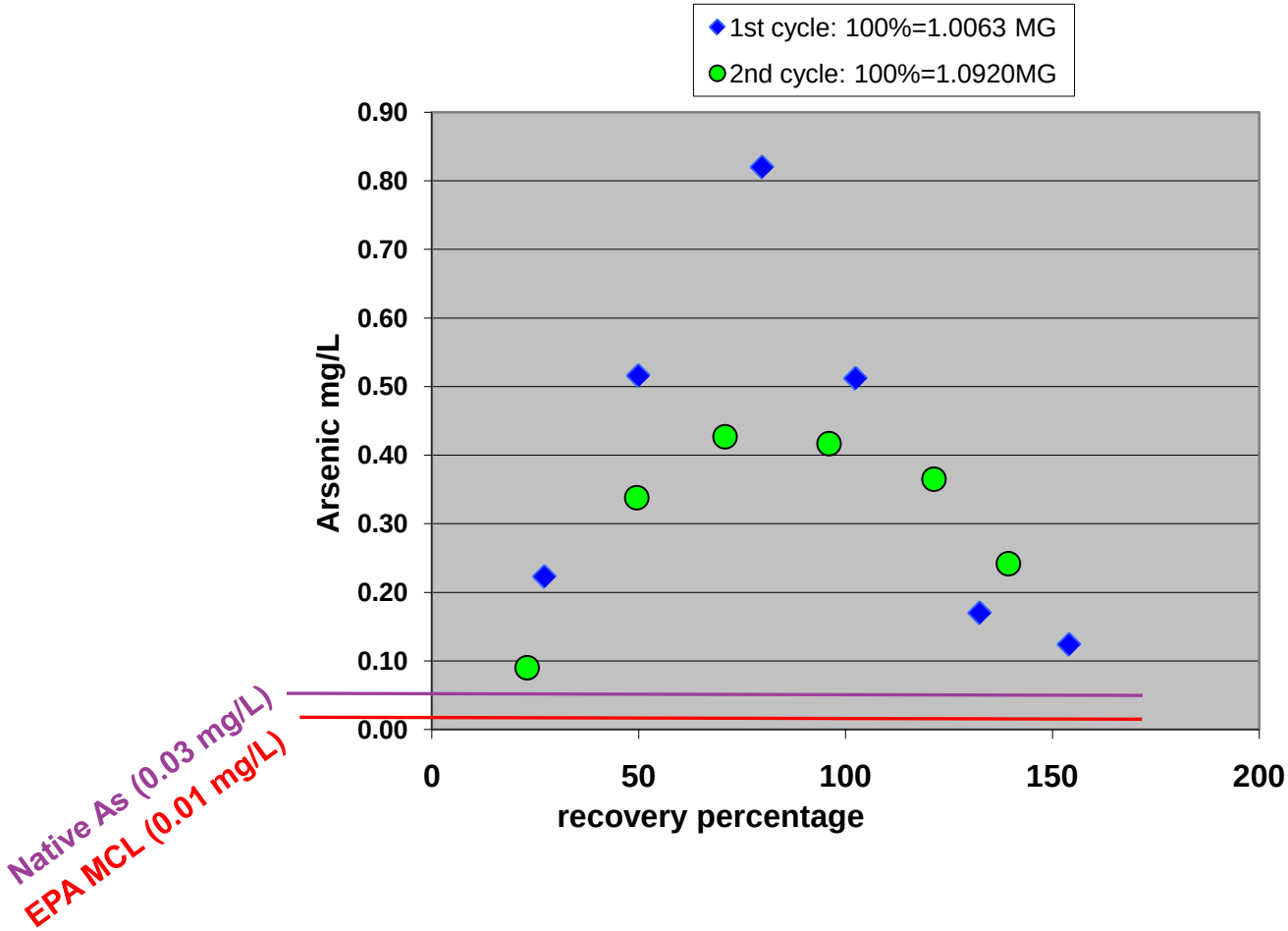
- **ASR wells require more attention than typical supply wells:**
  - **During Recharge cycle:** injection level monitoring & monthly flushing; may be monitoring requirements associated with permitting
  - **During Recovery:** increased water quality monitoring – somewhat less after few recovery cycles establish reliable recovery efficiency

ASR TEST CYCLES & ARSENIC MOBILIZATION





ASR TEST CYCLES & ARSENIC MOBILIZATION



UNITED WERCS PRE-TREATMENT INVESTIGATION PROJECT COMPONENTS

- **Literature Review**
  - A reference document for later tasks.
- **Core hole drilling at field to obtain:**
  - Continuous sample of aquifer material
  - Vertical profile of water chemistry variation
- **Mineralogical analyses**
  - Identification of arsenic source(s)
- **Identify laboratory experiments and perform**
  - Column testing of pre-treatment strategies to fix arsenic within aquifer matrix
- **ASR field tests**
  - To confirm bench-scale results for potentially successful “recipes”

PROJECT STATUS: FIELD & LAB WORK SO FAR

Arsenic distribution profile at field site aquifers has been determined.

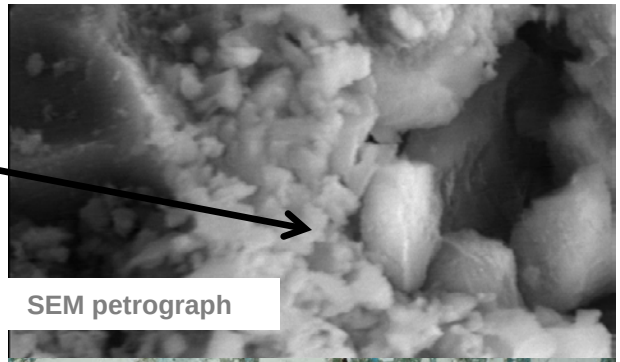
Bulk mineralogical report completed for cores obtained from field site test wells.

Characterization of field site aquifer redox conditions, water chemistry, mineralogy

Refined mineralogical testing (QEMSCAN) of cores being guided by project geochemists

aquifer core 236-237 ft.
XRF As concentration = 30 ppm

matrix material includes a mixture of amorphous (glass-rich) particulates and clay minerals

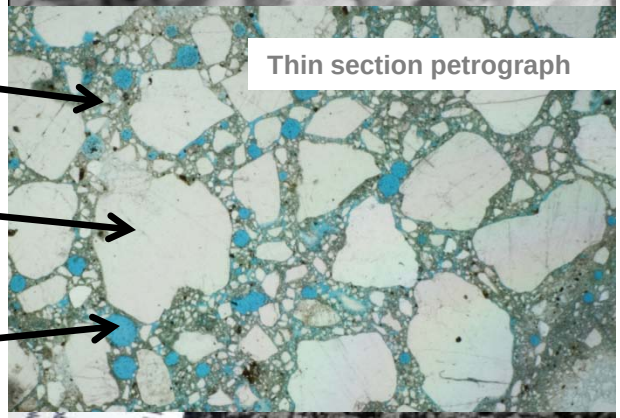


SEM petrograph

microporous matrix material

quartz sand grain

intergranular macroporosity



Thin section petrograph

Photo of aquifer material: unconsolidated, very poorly sorted, silt & clay-rich, subarkosic sandstone